PANDORA'S FALSE PROMISES

Busting the pro-nuclear propaganda

A BEYOND NUCLEAR REPORT
By Linda Pentz Gunter
www.BeyondNuclear.org

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EXECUTIVE SUMMARY

❒ Nuclear power, no matter the reactor design, cannot address climate change in time. In order to displace a significant amount of carbon-emitting fossil fuel generation, another 1,000 to 1,500 new 1,000+ Megawatt reactors would need to come on line worldwide by 2050, a completely prohibitive proposition.

❒ So-called "Generation IV" reactor designs, including "fast" or "small modular reactors," are the last gasp of a failing industry. Earlier versions of the fast breeder reactor were commercial failures and safety disasters. The ever soaring costs make nuclear power a financial quagmire for investors, and expensive new prototypes commercially unattractive.

❒ Proponents of the Integral Fast Reactor, overlook the exorbitant costs; proliferation risks; that it theoretically "transmutes," rather than eliminates, radioactive waste; that it is decades away from deployment; and that its use of sodium as a coolant can lead to fires and explosions.

❒ The continued daily use of nuclear power means continued risk of radiation exposure to surrounding populations, especially children who are vulnerable to leukemia when living close to reactors. Ionizing radiation released by nuclear power plants, either routinely or in large amounts, causes cellular damage and mutations in DNA, which in turn can lead to cancers and other illnesses.

❒ Low-ball health predictions after nuclear accidents are not reliable. The 2005 IAEA/WHO Chernobyl health report has been discredited for suppressing key data to justify low death predictions that do not stand up to scientific scrutiny. Furthermore, the IAEA has a mandate to promote nuclear technology. Given the long latency period of cancers caused by radiation exposure, it is too soon to accurately predict the ultimate health impacts from the Fukushima nuclear disaster, although some health effects are already being observed.

❒ The example of Germany — and numerous studies — demonstrates that both coal and nuclear can be phased out in favor of renewable energy. Jobs are more plentiful and enduring in the renewable sector. In Germany, renewable energy already employs 380,000 people compared to 30,000 in the nuclear sector.

❒ The argument that only nuclear provides "carbon-free," base load energy is out of date. Geothermal and offshore wind energy are capable of delivering reliable base load power with a smaller carbon footprint than nuclear energy. Energy efficiency is also an essential component in displacing nuclear and coal.

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Fast reactors are "expensive to build, complex to operate, susceptible to prolonged shutdown as a result of even minor malfunctions, and difficult and time-consuming to repair."

Admiral Hyman Rickover, 1956.

INTRODUCTION

The impetus for this document is the summer 2013 theatrical release of the pro-nuclear documentary film, *Pandora's Promise,* directed by Robert Stone. Its protagonists, both in the film and in their writing and public statements, broad brush the nuclear power industry in an almost entirely positive light.

The filmmakers originally promoted the film as *"anchored around the personal narratives of a growing number of leading former anti-nuclear activists,"* even though no one in the film fits this description. However, they have since modified this description, toned down the trailer and withdrawn the more detailed descriptions of the film's early thesis. Beyond Nuclear has tracked this on its *Pandora's False Promises* webpage.

Environmentalists cannot be pro-nuclear. It is precisely to protect their environment, that environmentalists ***oppose*** *nuclear energy — an extractive industry that destroys the natural environment, then contaminates it with radioactive releases and effluent. In Jaitapur, India, for example (protest pictured), a proposed mega-nuclear plant would destroy one of the world's most precious ecological hot spots and the pastoral and fishing communities there.*

The film's publicity campaign seizes on the theme "environmentalists for nuclear energy." Our contention is that, by definition, this is an impossibility. Environmentalists do not support extractive, non-sustainable industries and, in the case of nuclear, one that: poisons the environment and harms and kills uranium miners; depletes and radioactively contaminates water supplies; releases cancer-causing radioactive elements into the air, soil and water; creates radioactive waste containing elements deadly for hundreds to millions of years; and, if it goes wrong, can render vast areas permanent sacrifice zones indefinitely. A more accurate description of the film, therefore, would be "former environmentalists for nuclear energy."

The misleading arguments in the promotional materials and content of *Pandora's Promise* are of course not unique to the film and its spokespeople. They are universally (and often deliberately and knowingly) propagated myths and untruths — sometimes funded by the nuclear power industry — designed to advance the industry's financially-motivated agenda which has been largely bankrolled by American taxpayers for six decades.

The points made here address not only specific issues raised in the film but the arguments advanced by its protagonists and other nuclear proponents in a variety of different arenas and in the media. We also address the all-too-frequent "sin of omission." By selectively omitting key facts, a misleading impression can be given about the alleged "benefits" of nuclear power when including them would derail these arguments. Therefore, this document is intended to serve as a rebuttal to the universal and on-going sound bites propagated by the pro-nuclear propagandists.

This report is effectively a compilation — and a selection — of the enormous wealth of data available that show the inadequacies of nuclear power in addressing climate change along with its attendant high risks and exorbitant costs. While the report is divided into several sections by topic, these are by no means intended to be comprehensive and do not represent all the arguments in any particular category.

In particular, there is now extensive research — as well as plentiful examples of implementation — that show the capacity for renewable energy technologies to displace nuclear power as well as all traditional fossil fuel sources. Readers are best served by directing their attention to the experts in this field, some of whom are referenced in this report. The most compelling argument against the need to continue along the nuclear power path is made by the evidence of the technological, economical and environmental readiness of renewable energy to replace it.

For more comprehensive information on the respective topics covered here, we encourage readers to refer to the Beyond Nuclear website and to the sources cited and footnoted in the information that follows.

CLIMATE CHANGE

More than 380,000 new jobs have been created in the renewable energy sector in Germany which employs just 30,000 in the nuclear sector.

No time for nuclear

- Climate change has become an urgent crisis that must be met immediately using clean, green energy technologies that are available now. We do not have time to bring on slow, cumbersome nuclear power plants that take years to build.[1]

The climate crisis must be addressed immediately with non-carbon-emitting, non-extractive technologies that do not produce toxic waste. This means phasing out nuclear power and fossil fuels including coal, oil and gas, and replacing these with sustainable energy, energy efficiency and conservation. Numerous studies have shown that we cannot reduce carbon emissions in time using slow, expensive and dangerous nuclear energy. But wind, solar, geothermal and other renewable sources are readily available.
(Photo: Sepp Friedhuber.)

- Nuclear power is an inefficient and risky way to address climate change.[2] A 2003 MIT study concluded that in order to displace a significant amount of carbon-emitting fossil-fuel generation, another 1,000 to 1,500 new reactors (1,000 MW or larger) would need to come on line worldwide by 2050, more than two new reactors every month,[3] an unrealistic and impracticable proposition.

- According to the PRIS database of the International Atomic Energy Agency, there were 437 nuclear power reactors in operation worldwide as of March 31, 2013, with a generating capacity of 373,156 MW.[4] Therefore, in less than 40 years, the world would

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[1] http://beyondnuclear.squarespace.com/storage/fs_climate_chaos_and_nuclear_power.pdf. *Climate Chaos and Nuclear Power.* A Beyond Nuclear Fact Sheet. 2008.

[2] http://ieer.org/resource/books/insurmountable-risks-dangers-nuclear/. *Insurmountable Risks: The Dangers of Using Nuclear Power to Combat Global Climate Change.* By Brice Smith. IEER books. May 2006.

[3] http://web.mit.edu/nuclearpower/pdf/nuclearpower-summary.pdf. *The Future of Nuclear Power.* MIT. 2003.

[4] http://prisweb.iaea.org/Wedas/WEDAS.asp. Power Reactor Information System.

have to build double to more than triple the amount of nuclear power reactors built and operated in the past 60 years.[5]

- Given the urgency of the climate crisis, it makes no sense to turn to technologies like the "burner" version of the Integral Fast Reactor (IFR) promoted by *Pandora's Promise* that does not exist anywhere in the world. Energy efficiency measures are the essential first step followed by renewables, and can be implemented faster, at lower economic cost, and with fewer social and environmental impacts than any conventional energy supply-side options.[6]

- Climate scientists, (including James Hansen[7] who promotes so-called Generation IV reactors like the IFR), warn that we are fast running out of time to reduce carbon emissions before runaway climate change could become impossible to mitigate.[8] Yet Gen. IV reactors are theoretically decades away from a deployed reality which will come at an enormous price tag more reliably spent on clean, safe energy alternatives.

The renewables and energy efficiency alternatives

- The implementation of energy efficiency measures and renewable energy is not a technical – but a political – challenge. Numerous studies show that wind and solar energy alone could produce orders of magnitude more electricity than currently used by US consumers and industry.[9][10]

- In the landmark 2007 study, *Carbon-Free and Nuclear-Free: A Roadmap for US Energy Policy,* Dr. Arjun Makhijani noted: *"The U.S. renewable energy resource base is vast and practically untapped. Available wind energy resources in 12 Midwestern and Rocky Mountain states equal about 2.5 times the entire electricity production of the United States. North Dakota, Texas, Kansas, South Dakota, Montana, and Nebraska each have wind energy potential greater than the electricity produced by all 103 U.S. nuclear power plants. Solar energy resources on just one percent of the area*

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[5] Personal communication to author from David Lochbaum, Union of Concerned Scientists.

[6] Email communication to author from Ken Bossong. April 10, 2013.

[7] http://transitionvoice.com/2011/03/censored-scientists-dirty-politics-and-the-nuclear-distraction/ *Censored scientists, dirty politics and the nuclear distraction.* By Erik Curren. Transition Voice. See excerpt from Hansen's book *Storms of my Grandchildren*. March 11, 2011.

[8] http://www.nature.com/nclimate/journal/vaop/ncurrent/full/nclimate1758.html. *2020 emissions levels required to limit warming to below 2°C.* Rojeli et al. Nature Climate Change. December 16, 2012.

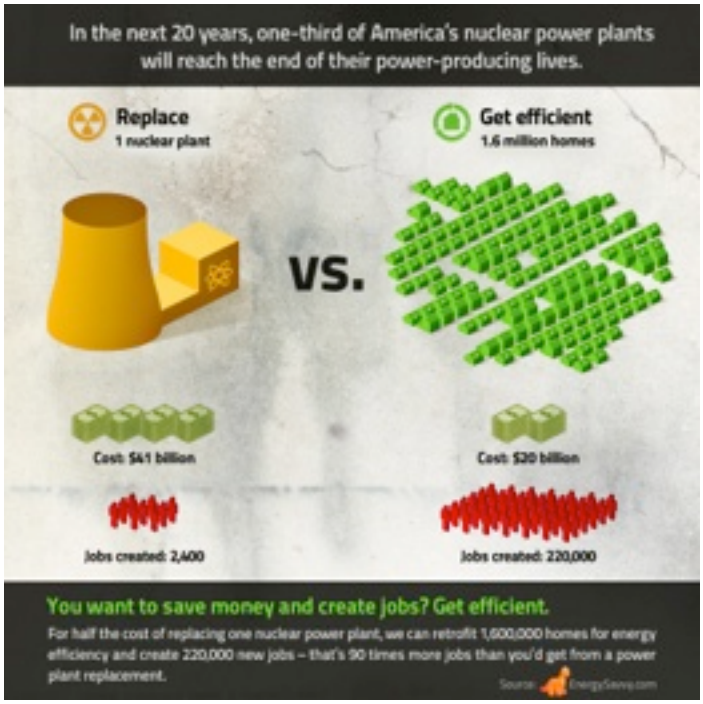
[9] http://www.beyondnuclear.org/storage/seabrook-renewables/seab_lra_09202010_exhibit_dahger_powerpoint06182009a.pdf *Deepwater Offshore Wind in Maine: the Plan, the Timeline.* By. Dr. H.J. Dagher, P.E. University of Maine. June 18, 2009.

[10] http://ieer.org/wp/wp-content/uploads/2012/07/16-3.pdf *Renewable Energy Roadmap for Utah.* By Arjun Makhijani. IEER. July 2012.

of the United States are about three times as large as wind energy, if production is focused in the high insolation areas in the Southwest and West."[11]

- The Rocky Mountain Institute's report, *Reinventing Fire*, showed "how to run a 2.6-fold-bigger U.S. economy by 2050 with no oil, coal, or nuclear energy, one-third less natural gas, a $5 trillion dollar net savings, 82-86 percent lower carbon emissions, and no new inventions, with the transition led by business for growth and profit."[12]

  - *According to EnergySavvy, for half the cost of replacing one traditional light-water nuclear power reactor we can retrofit 1.6 million homes for energy efficiency and create 220,000 jobs — 90 times more jobs than created by a reactor replacement. By using power more efficiently, particularly in our homes, we can avoid replacing aging nuclear power plants entirely.*[11]



- Conservatively, energy efficiency can save at least 44 percent of projected 2050 electricity needs through proven building and industrial technologies that pay back far faster than any new source of supply. Wasting far less energy and getting the rest at lower and stable prices would powerfully boost jobs and growth.[13] Cutting energy use in half (or even more) with cost-effective and currently-available technologies probably could be accomplished before 2050. With simple life-style changes, the numbers could be even more dramatic.[14]

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[11] http://www.ieer.org/carbonfree/ *Carbon-Free and Nuclear-Free: A Roadmap for US Energy Policy.* By Arjun Makhijani. 2007.

[12] http://www.rmi.org/ReinventingFire. *Reinventing Fire.* Rocky Mountain Institute.

[13] http://www.huffingtonpost.com/amory-lovins/climate-change-no-breakth_b_2654248.html?view=print&comm_ref=false *Climate Change: No Breakthroughs Needed, Mr. President.* By Amory Lovins. Co-authored with Thomas Dinwoodie. The Huffington Post. February 19, 2013.

[14] Ibid. Email to author from Ken Bossong.

- Energy conservation is one of the prerequisites for a future powered by renewables. We will not be able to meet the needs of our planet's expected nine billion inhabitants if we continue to use energy as wastefully as we do today. It is the single most important element.[15]

The power of nuclear lobbying

- The United States squandered the opportunity early on to lead the world in the renewable energy sector. In 1952, President Truman's Paley Commission — named after its chairman – concluded that nuclear power could deliver only a *"modest fraction of American energy requirements at best."* Instead, the commission strongly recommended *"aggressive research in the whole field of solar energy – an effort in which the United States could make an immense contribution to the welfare of the world."*[16] But the incoming Eisenhower administration succumbed to military and industry pressure, embarking on the *"Atoms for Peace"* program instead.

- The lobbying power of the fossil fuel and nuclear industries has impeded progress of renewable energy in the US for decades. In 2008, the Nuclear Energy Institute (NEI) spent $2,360,000 lobbying Congress, their highest tally to date.[17] In 2012, NEI spent $2,315,000.[18] Between 1999 and 2009 the nuclear power industry spent $645 million in federal lobbying and nearly another $65 million in federal campaign contributions.[19] This equates to a staggering $1.36 million a week for a decade.

THE BASE LOAD MYTH

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[15] http://wwf.panda.org/what_we_do/footprint/climate_carbon_energy/energy_solutions/renewable_energy/sustainable_energy_report/. *The Energy Report. 100% Renewable Energy by 2050.* WWF and Ecofys. 2011

[16] *The Report of the President's Materials Policy Commission.* William S. Paley. (Washington, DC: Government Printing Office, June 1952).

[17] http://www.opensecrets.org/lobby/clientsum.php?id=D000000555&year=2008 Open Secrets. Center for Responsive Politics.

[18] Ibid.

[19] http://www.beyondnuclear.org/storage/kevin_media_statement_kerry_lieberman_5_12_2010.pdf *Media Statement by Kevin Kamps of Beyond Nuclear regarding the Kerry-Lieberman "Climate" Bill.* May 12, 2010.

"Base load capacity is going to become an anachronism." Jon Wellinghoff, chairman, Federal Energy Regulatory Commission.

- The argument that nuclear power is needed to provide base load electricity because the sun does not always shine and the wind does not always blow is an over-simplification that has become out of date.[20]

- Analysis and experience show that 60-80 percent solar and wind power —sited across a region, forecasted, and balanced by flexible supply and demand — can keep the lights on with often less storage or backup than traditional giant power stations.[21]

- The World Wildlife Fund and Ecofys released a study in 2011 that mapped out how the entire planet could run entirely on renewable energy by 2050.[22] (And see studies by Jacobson and Delucchi).[23]

- The Department of Energy's National Renewable Energy Laboratory (NREL) views geothermal[24] and wind energy as capable of providing base load electricity, overcoming wind energy intermittency issues *"with energy storage and long-distance transmission"* to *"provide a source of power that is functionally equivalent to a conventional baseload electric power plant."*[25]

- According to NREL, *"a 'baseload wind' system can produce a stable, reliable output that can replace a conventional fossil or nuclear baseload plant, instead of merely supplementing its output."*[26]

- Large, capital-intensive nuclear or coal-fired power plants were an inefficient choice from the start. Because they cannot power up quickly, they run at high capacity during the day but also at night when energy demand is much lower.

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[20] *Renewables Global Futures Report 2013.* Renewable Energy Policy Network for the 21st Century (REN21) and Institute for Sustainable Energy Policies (isep).

[21] Ibid. *Climate Change: No Breakthroughs Needed, Mr. President.*

[22] Ibid. *The Energy Report. 100% Renewable Energy by 2050.*

[23] http://www.stanford.edu/group/efmh/jacobson/Articles/I/JDEnPolicyPt1.pdf *Providing all global energy with wind, water, and solar power, Part I: Technologies, energy resources, quantities and areas of infrastructure, and materials.* Mark Z. Jacobson and Mark A. Delucchi. Energy Policy. December 30, 2010.

[24] http://www.nrel.gov/docs/fy11osti/50172.pdf *A Broad Overview of Energy Efficiency and Renewable Energy Opportunities for Department of Defense Installations.* Anderson et al. National Renewable Energy Laboratory. August 2011.

[25] http://pbadupws.nrc.gov/docs/ML1001/ML100151731.pdf. *Creating Baseload Wind Power Systems Using Advance Compressed Air Energy Storage Concepts.* National Renewable Energy Laboratory. October 3, 2006.

[26] Ibid.

- Combined together, in many regions, peak wind and solar production match up well with peak electricity demand.[27]

- Base load is not necessarily the answer. Greater emphasis on distributed renewable energy systems (e.g., rooftop solar, geothermal heat pumps) and micro-grids may lessen the base load issue as well as reduce electrical demand overall.[28]

- In 2009, Federal Energy Regulatory Commission chairman, Jon Wellinghoff said *"base load capacity is going to become an anachronism,"* and that *"we may not need any, [nuclear or coal plants] ever."*[29]

- A new study by the German engineering association, VDE, shows that *"renewables completely 'obliterate' the need for base load power."*[30]

- Moving to distributed generation provided by renewable energy makes particular sense in developing areas of the world with more sparse populations and where major energy infrastructure is not readily available. For example, India has a grid penetration of 65% which is low compared to other developed and even developing nations. This low-grid connectivity effect is worsened by the fact that more than 70% of the population lives in rural India. These factors provide India a unique opportunity to exploit decentralized electricity production.[31]

- Distributed generation also makes sense in developed countries. In Germany, the cooperative model is being successfully utilized for renewable energy production – there is literally a rural energy revolution underway. These energy cooperatives will aid in the country's transition from a centralized energy system based on fossil fuels to one supplied by distributed renewable energy.[32]

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[27] http://www.skepticalscience.com/print.php?r=374 *Can renewables provide baseload power?* By John Cook, Climate Communication Fellow for the Global Change Institute at the University of Queensland, Australia.

[28] Ibid. Email to author from Ken Bossong.

[29] http://www.rockymtnsolar.com/pdf/Energy_Regulatory_Chief.pdf. *Energy Regulatory Chief Says New Coal, Nuclear Plants May Be Unnecessary.* By Ben Geman and others. Greenwire. April 22, 2009.

[30] http://cleantechnica.com/2012/10/09/german-study-not-much-power-storage-or-coal-power-needed-for-40-renewable-power-supply/ *German Study: Not much power storage or coal power needed for 40% renewable power supply.* Clean Technica. October 9, 2012.

[31] http://www.wipro.org/earthian/documents/1000925_IITKGP_RE_Paper.pdf *Impact analysis of distributed and RE based distributed generation on Indian economy and economy of BoP.* By A. Parashar, M. Shah and P.K. Das. Institute of Technology Kharagpur, India. 2010.

[32] http://www.boell.org/web/139-Amanda-Bilek-Revitalizing-Rural-Communities-through-Renewable-Energy-Cooperative.html *Revitalizing Rural Communities through the Renewable Energy Cooperative.* By Amanda Bilek. Heinrich Böll Stiftung. June 2012.

THE "NEW GENERATION" FAST REACTOR

"The future of the IFR in this country is nonexistent."[33] Dr. Charles Till, former Associate Laboratory Director for Engineering Research at Argonne National Laboratory and featured in *Pandora's Promise.*

- The Integral Fast Reactor (IFR), formerly the Advanced Liquid Metal Reactor, was originally designed at the Argonne National Laboratory. It would use fast neutrons and no moderator and would require pyroprocessing at the reactor site. The IFR was canceled by the US Congress in 1994.

- Claims that the IFR would be "meltdown proof" can be challenged. *"The main problem is that it is impossible to prove that all possible accidents have been conceptualized and the reactor's behavior evaluated under each of those accident conditions. Even evaluating the behavior of a reactor under one severe accident condition is extremely complex. Unless the modeling results are critically evaluated, one cannot conclude that assertions of safety made by the designer are valid. In the case of the Indian fast breeder reactor, this was found not to be true. Such an evaluation has not been done for the IFR."*[34]

- The IFR cannot magically devour all civilian and military radioactive waste. If used as a "burner" it can theoretically "transmute" these wastes by reducing the proportion of long-lived isotopes contained in the waste. But radioactive fission products would remain, some of which are very long-lived. Management of these radioactive wastes would still be necessary for several hundred years. (For more, see the *Waste* section.)

- The IFR would use highly reactive sodium as a coolant. This sets up the risk of fire, explosions and super-criticality accidents.[35] A rapid power increase inside the core of an IFR could vaporize the fuel and blow the core apart.[36]

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[33] http://www.pbs.org/wgbh/pages/frontline/shows/reaction/interviews/till.html. Nuclear Reaction interview with Dr. Charles Till. Frontline. PBS. Undated.

[34] Communication to author from M.V. Ramana. January 23, 2013.

[35] http://ieer.org/wp/wp-content/uploads/2000/05/Annie-statement-transmu.pdf *The Nuclear Alchemy Gamble: An Assessment of Transmutation as a Nuclear Waste Management Strategy.* Statement of Annie Makhijani, Project Scientist, Institute for Energy and Environmental Research, May 24, 2000.

[36] E.E. Lewis, *Nuclear power reactor safety* (New York: Wiley, 1977), pp. 245–261.

- Practically all sodium-cooled fast reactors constructed so far have suffered sodium leaks and fires including Fermi I in the US.[37]
- Perhaps the most dramatic example of a sodium-cooled fast reactor disaster is the Monju fast reactor in Japan that in 1995 suffered a drastic sodium leak from the secondary cooling circuit that caused a major fire and closed the reactor for more than 14 years. It reached criticality again in 2010 only to be shut down after heavy machinery was dropped into the reactor core.

- The saga of Monju illustrates the impracticality of the sodium-cooled reactor in not only addressing climate change but simply in generating electricity. Monju took nine years after construction began just to come on line. To date, it has generated *just one single hour* of electricity.[38] Meanwhile it has cost *$10.11 billion* for that one hour.[39]

- The IFR is untried and untested. The concept of using a breeder reactor as a "burner" was first advanced during the G.W. Bush administration under his Global Nuclear Energy Partnership (GNEP) initiative that was established in 2006.[40] GNEP was put on indefinite hold by the Obama administration which zeroed out its funding although significant taxpayer-funded research and development for reprocessing continues.[41] The House Subcommittee on Energy and Water Development described GNEP as "counterproductive, poorly designed, and poorly executed."[42]

- The sole IFR design under consideration — GE-Hitachi's PRISM — has no final safety assessment for licensing purposes. In the early 1990s, GE submitted a pre-application to the US Nuclear Regulatory Commission (NRC) whose staff identified a number of concerns including the fact that the PRISM has a positive sodium void coefficient.[43]

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[37] http://www.princeton.edu/sgs/publications/articles/Time-to-give-up-BAS-May_June-2010.pdf *It's time to give up on the breeder reactor. The Bulletin of the Atomic Scientists.* By Thomas B Cochran, Harold A. Feiveson, Zia Mian, M.V. Ramana, Mycle Schneider and Frank N. von Hippel. May/June 2010.

[38] http://www.greenaction-japan.org/modules/english0/index.php?id=7 What is Monju? Green Action, Japan.

[39] http://en.wikipedia.org/wiki/Monju_Nuclear_Power_Plant Monju Nuclear Power Plant. Wikipedia.

[40] *Overview: The Rise and Fall of Plutonium Breeder Reactors*. By Frank von Hippel. Fast Breeder Reactor Programs: History and Status. International Panel on Fissile Materials. February 2010.

[41] http://www.taxpayer.net/library/article/doe-halts-plan-for-commercial-reprocessing-global-nuclear-energy-partnershi *DOE Halts Plan for Commercial Reprocessing: Global Nuclear Energy Partnership Shelved*. Taxpayers for Common Sense. July 27, 2009.

[42] Ibid.

[43] A positive void coefficient refers to how much the reactivity changes as voids (usually steam bubbles) form in the coolant. If the coolant (in this case sodium) boils, it creates voids inside the reactor. The change in reactivity caused by a change of voids inside the reactor is proportional to the void coefficient. A positive void coefficient means that the reactivity increases as the void content inside the reactor increases due to increased boiling or loss of coolant. This could result in all the coolant boiling which is what occurred at the RBMK Unit 4 reactor at Chernobyl which had a positive void coefficient when operating at low power levels. (Light-water reactors and boiling water reactors have a negative void coefficient which can also create risks.)

- Suggestions that the IFR could be developed as a “small modular reactor” (SMR) does not mean the reactor will be safer and represents misconceptions about the practical utility of small modular reactors. At least two of the proposed SMR designs in the US “*have no motor-driven pumps and depend entirely on natural circulation for*

Long suppressed video footage of the 1995 Monju fire revealed the disaster to be more serious than originally described. The video shows men in silver "space suits" exploring the reactor in which sodium compounds hang from the air ducts like icicles. (Source: Wikileaks.)

cooling – frankly, a risky business in view of the uncertainties and challenges of injecting water into overheating reactors and spent fuel pools that were seen during Fukushima.”[44] Furthermore, small scale reactors will contribute even less and taken even longer in off-setting carbon emissions. (And see the *Costs* section, page 18).

- A cadre of experts trained in transuranic chemistry and plutonium metallurgy could separate out the plutonium from the other transuranic elements using hot cells and other facilities on site.[45]

- The operation of an IFR requires a pyro-processing facility. Pyro-processing produces impure plutonium (then used as fuel for the IFR) that is mixed with other elements. However, the elements that the plutonium is mixed with are not radioactive enough to deter theft. This material, therefore, would still be attractive to states and others lacking access to pure plutonium. And some of these same elements are also weapons-usable. This further increases and exacerbates the global proliferation dangers with which we are already confronted.

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[44] http://allthingsnuclear.org/does-does-funding-announcement-mark-the-end-of-its-irrational-exuberance-for-smrs/. *Does DOE’s Funding Announcement Mark the End of its Irrational Exuberance for SMRs?* By Dr. Edwin Lyman. Union of Concerned Scientists. November 21, 2012.

[45] http://www.princeton.edu/sgs/publications/sgs/archive/17-2-3-Cochran-Feiv-vonHip.pdf *Fast Reactor Development in the United States.* By Thomas B. Cochran, Harold A. Feiveson, and Frank von Hippel. Fast Breeder Reactor Programs: History and Status. International Panel on Fissile Materials. February 2010.

- Pyro-processing is expensive. The pyro-processing of 2.65 tons of sodium-bonded spent fuel at the Idaho National Laboratory was estimated to cost $234 million over eight years, including waste processing and disposal for a reprocessing cost of approximately $88,000/kg.[46]

- Using IFR technology as a "global solution" to climate change, increases proliferation risks, particularly in countries which use nuclear power but do not possess nuclear weapons. The IFR technology could provide a non-nuclear weapons state with access to tons of plutonium in each co-located reactor and reprocessing facility.[47]

- Such a tempting means to transition to military nuclear weapons production could have even more immediate climate consequences for the planet than climate change itself. For example, a limited nuclear war between two countries using 50 Hiroshima-sized bombs each, *"could produce so much smoke that temperatures would fall below those of the Little Ice Age of the fourteenth to nineteenth centuries, shortening the growing season around the world and threatening the global food supply."*[48]

- For further details on the flaws in the IFR concept, see the Beyond Nuclear Fact Sheet, *Integral Fast Reactor: Facts and Myths*,[49] and other sources cited here.

- Other "new" reactors — including those using thorium fuel — are being promoted in an attempt to prolong the use of nuclear power plants. None of these is close to reality. For more on the myths about thorium-fueled reactors, see: *Ten Myths about Thorium as a Nuclear Energy Solution*[50] and Dr. Gordon Edwards' analysis, *Thorium Reactors: Back to the Dream Factory*.[51]

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[46] Ibid. *Fast Reactor Development in the United States*

[47] Ibid.

[48] http://climate.envsci.rutgers.edu/pdf/RobockToonSAD.pdf *Self-assured destruction: The climate impacts of nuclear war.* By Alan Robock and Owen Brian Toon. The Bulletin of the Atomic Scientists. 2012.

[49] http://www.beyondnuclear.org/storage/documents/BN_Final_FullFactsheet_IFR_Jan2013.pdf. *Integral Fast Reactors: Facts and Myths.* A Beyond Nuclear Fact Sheet. January 2013.

[50] http://www.beyondnuclear.org/storage/documents/THE%20MYTHS%20ABOUT%20THORIUM%20AS%20A%20NUCLEAR%20ENERGY%20SOLUTION.pdf Ten Myths about Thorium as a Nuclear Energy Solution. A Beyond Nuclear Fact Sheet.

[51] http://www.ccnr.org/Thorium_Reactors.html *Thorium Reactors: Back to the Dream Factory.* By Gordon Edwards, July 13, 2011.

WASTE

"There is no magic bullet for solving the problems of long-lived nuclear waste." Dr. Arjun Makhijani, President, Institute for Energy and Environmental Research.

- The first step to solving the problem of nuclear waste is to stop making it.
- Assertions that the IFR *"once loaded with nuclear waste, can, in principle, keep recycling it until only a small fraction remains,"*[52] ignore some inconvenient realities. Although the National Academy of Sciences acknowledges in a 1996 study that the waste inventory could be reduced, it also points out that such an effort would have very high costs and marginal benefits and would take hundreds of years.[53]
- The IFR does not eliminate the nuclear waste that has piled up so much as theoretically transmute it. Transmutation describes the process of reducing the proportion of long-lived isotopes contained in the waste. While the proportion of elements such as plutonium, americium and curium may be reduced, radioactive fission products would remain, including cesium, krypton-87 and strontium-90. Management of these radioactive wastes would still be necessary for several hundred years at least. Transmutation also creates huge volumes of "low level" and transuranic waste.[54]
- Therefore, even with a fleet of such fast reactors, nations would still require a final permanent "disposal" facility for radioactive waste.[55]
- How much space radioactive waste takes up is not the issue. It is the duration and concentration of the lethality of its content that is relevant. Depending on its isotopic content, radioactive waste can remain deadly even longer than a million years.

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[52] http://www.monbiot.com/2012/02/02/nuclear-vs-nuclear-vs-nuclear/. *Nuclear vs Nuclear vs Nuclear.* By George Monbiot. Monbiot.com. February 2, 2012.

[53] http://www.nap.edu/openbook.php?isbn=0309052262 *Nuclear Wastes: Technologies for Separations and Transmutation.* National Academy of Sciences. National Academy Press. 1996.

[54] Transuranic waste is waste contaminated with alpha-emitting transuranic radionuclides with half-lives longer than 20 years and in concentrations greater than 3.7MBq/kg. Transuranic elements have atomic numbers greater than uranium (92) and are typically man-made.

[55] http://www.scientificamerican.com/article.cfm?id=fast-reactors-to-consume-plutonium-and-nuclear-waste&page=3 *Can Fast Reactors Speedily Solve Plutonium Problems?* By David Biello. Scientific American. March 21, 2012.

COSTS

"*To date, fast neutron reactors have consumed six decades and $100 billion of global effort but remain 'wishful thinking.'"* David Biello, Scientific American.[56]

- Claims that the IFR would be *"more economical to produce than today's highly complex Light Water Reactors (LWR)"*[57] are unfounded. For 'demonstration' liquid-sodium-cooled reactors, the capital costs per kilowatt generating capacity have typically been more than twice those of comparable water-cooled reactors.[58] New reactor designs are not economically competitive even with a conventional LWR.[59]

- With nuclear utilities abandoning nuclear power plants as a bad business proposition, it is highly unlikely that there would be interest in pursuing an even more expensive and less commercially viable option like the IFR.

- Public subsidies for nuclear power have flowed for more than 50 years, to the tune of hundreds of billions of dollars.[60] Production of the IFR would once more burden taxpayers with the brunt of these high costs. The only SMR project currently funded will rely on taxpayer subsidies to offset high production costs.

- Using the IFR as an SMR further exacerbates its poor economics. Writes Dr. Edwin Lyman of UCS: *"Based on economies of scale, small reactors will produce more expensive electricity than large reactors, all other factors being equal. To compensate for this basic principle, SMR vendors argue they can achieve economies of mass production that would reduce capital costs. But even if this assertion were true, these benefits would not be realized for the first few units."*[61]

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[56] http://www.scientificamerican.com/article.cfm?id=are-new-types-of-reactors-needed-for-nuclear-renaissance *Are New Types of Reactors Needed for the US Nuclear Renaissance?* By David Biello. Scientific American. February 19, 2010.

[57] http://www.beyondnuclear.org/storage/PANDORAS-PROMISE-brief-synopsis1.pdf *Pandora's Promise a film by Robert Stone.* Originally found on, but since removed from Robert Stone Productions website.

[58] Ibid. *Overview: The Rise and Fall of Plutonium Breeder Reactors*.

[59] Ibid. *It's time to give up on the breeder reactor.*

[60] http://www.ucsusa.org/assets/documents/nuclear_power/nuclear_subsidies_report.pdf *Nuclear Power: Still Not Viable without Subsidies.* Union of Concerned Scientists. 2011.

[61] Ibid. *Does DOE's Funding Announcement Mark the End of its Irrational Exuberance for SMRs?*

NUCLEAR POWER AND HEALTH RISKS

"It is important to defend post-nuclear-accident health data from those who would seek to deny, obscure, or even destroy it." Dr. John Gofman.

Medical realities of radiation exposure

- Nuclear power plants routinely release radioactivity due to normal operations that accumulates and magnifies up the food chain in the environment. The levels increase significantly with accidental leaks and spills and dramatically due to major accidents.

- Ionizing radiation causes cellular damage and mutations in DNA, which in turn can lead to cancer. Ionizing radiation occurs in two forms — waves or particles.[62]

An early photograph of Dr. John Gofman at work. Dr. Gofman and his colleague, Dr. Arthur Tamplin, studied the health effects of radiation. By 1990 Dr. Gofman had proven beyond a reasonable doubt that there was no threshold level below which doses of ionizing radiation to the human body were safe. In other words, there is no safe dose.

- Exposure to radiation is not an immediate killer unless received in a very large dose. However it is clinically shown that long-term, low-level exposure causes cellular damage and changes in DNA that can be passed on to offspring. In addition, teratogenic mutations can occur when a fetus is exposed in the uterus.[63]

- Latent cancers caused by exposure to radiation can – and often do – take years or even decades to manifest.[64] The lower the radiation level, the longer the latency period before the outbreak of cancer.[65]

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[62] http://www.who.int/ionizing_radiation/about/what_is_ir/en/ *What is Ionizing Radiation?* World Health Organization.

[63] http://www.epa.gov/radiation/understand/health_effects.html U.S. Environmental Protection Agency, Dept. of Radiation Protection. *Health Effects.*

[64] Dr. Ian Fairlie, personal communication to author. April 10, 2013. And see: http://www.ianfairlie.org/. Dr. Ian Fairlie, independent consultant on radioactivity in the environment.

[65] http://www.ratical.org/radiation/Chernobyl/HEofC25yrsAC.html *Health Effects of Chernobyl. 25 years after the reactor catastrophe.* German affiliate of International Physicians for the Prevention of Nuclear War. April 8, 2011.

- Radiation's non-targeted effects, such as genomic instability, mini-satellite mutations and bystander effects, are still being studied and many scientists think that radiation risk estimates should be increased to take these effects into account.[66]

- Children are more susceptible to ionizing radiation and other environmental pollutants than adults, and may suffer from health consequences for longer time periods.[67]

- Current radiation standards are based on "permissible" exposure limits for a healthy, Caucasian, adult male in his 20s-30s, and need to be revised to protect the most susceptible populations, such as pregnant women and lactating mothers.[68]

Radiation in the environment

- Serious accidents can occur at any stage of the uranium fuel chain. Reactor accidents have garnered the most worldwide attention but there are other examples. Reprocessing disasters in the former Soviet Union and uranium mining accidents in North America have had devastating environmental and health results.

- In 1957, a container of radioactive waste exploded at the Mayak reprocessing plant in the Ural mountains, sending clouds of high-level radioactive gas into the atmosphere. The site is one of the most radioactively contaminated places on Earth. Generations of residents suffer from sterility, cancer, asthma, and other illnesses.[69]

- In the late 1970s, contamination from the Elliot Lake, Ontario, uranium mill tailings had killed virtually all life in the 18 lakes of the 58-mile-long Serpent River System. The International Joint Commission found that the Elliot Lake tailings were the largest source of radium contamination in the Great Lakes.[70] The 1979 Church Rock, NM uranium mine tailings spill spewed 90 million gallons of radioactive effluent and 1,100 tons of solid mill wastes into the Rio Puerco, permanently contaminating the river.[71]

- Studies have shown strong evidence for an increased risk for lung cancer in Native American uranium miners — over 3 times more lung cancer deaths than expected. [72]

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[66] Ibid. Dr. Ian Fairlie, personal communication to author.

[67] Ibid. U.S. Environmental Protection Agency, Dept. of Radiation Protection. *Health Effects.*

[68] http://ieer.org/projects/healthy-from-the-start/. See Healthy From The Start campaign for more information.

[69] http://www.rferl.org/content/article/1063825.html *Russia: Living - and Dying - in the Shadow of Mayak.* By Alik Gilmulin. May 13, 2013.

[70] Source: Dr. Gordon Edwards.

[71] http://beyondnuclear.squarespace.com/storage/Remembering_Church_Rock_July162009.pdf. *Remembering Church Rock: America's forgotten nuclear accident.* By Linda Gunter. Undated.

[72] http://www.cdc.gov/niosh/pgms/worknotify/uranium.html. *Worker Health Study Summaries*. Centers for Disease Control and Prevention. 2000.

Stanrock Mill Tailings Area, Elliot Lake, Ontario, 1986. The 30-foot high wall of white sand behind the trees is made up of uranium tailings. Over 130 million tons of these tailings have been deposited in the Elliot Lake region and have contaminated the entire 58-mile long Serpent River system, finding their way into Lake Huron. (Photo: Robert Del Tredici.)

- The operation of French-owned uranium mines in Niger have depleted already scarce water supplies, essential for the local Tuareg's pastoral and agrarian way of life.[73] Impoverished populations, desperate for resources, have used discarded metals from the mines — which turned out to be radioactive — as household goods. Rocks found outside the local hospital in Arlit, one of the main mining towns, were found to be 100 times more radioactive than background when tested by the CRIIRAD laboratory.

- The nuclear sector does not just kill people and animals. It is also responsible for killing cultures and traditional ways of life. Radium and other radioactive and toxic heavy metal contamination from mines and mills have poisoned Native Americans' and First Nations' traditional food supplies – moose, fish, and other wildlife.[74] Aboriginal populations in Australia have been similarly affected.[75]

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[73] http://www.irinnews.org/Report/83706/NIGER-Desert-residents-pay-high-price-for-lucrative-uranium-mining *Niger: Desert residents pay high price for lucrative uranium mining.* IRIN. March 30, 2009.

[74] http://www.miningwatch.ca/my-homeland-stories-effects-nuclear-industries-people-review *This is My Homeland: Stories of the effects of nuclear industries by people.* Edited by Lorraine Rekmans, Keith Lewis and Anabel Dwyer. Serpent River First Nation. December 2, 2006.

[75] http://en.wikipedia.org/wiki/Uranium_mining_in_Kakadu_National_Park. *Uranium mining in Kakadu National Park.* Wikipedia and other sources cited.

Medical integrity and the World Health Organization (WHO)

- The evaluation of health impacts of accidents – as well as routine releases of radiation from operating nuclear fuel chain facilities – should be performed in a transparent manner by individuals and organizations independent of nuclear utilities.

The World Health Organization (WHO), headquartered in Geneva, Switzerland, is effectively gagged by the nuclear-promoting International Atomic Energy Agency (IAEA). Therefore, WHO analyses on the health impacts of nuclear accidents lack credibility. Vassili Nesterenko (pictured), a nuclear physicist and vice-president of Children of Chernobyl Belarus, helped maintain a vigil outside WHO headquarters until his death in August 2008. He was also the co-author of a comprehensive study that looked at the likely deaths to be caused by the Chernobyl disaster, estimating an eventual total of close to one million people. A liquidator himself, he helped fight the Chernobyl fire from a helicopter.

- As Dr. John Gofman noted, *"it is important to defend post-nuclear-accident health data from those who would seek to deny, obscure, or even destroy it."*[76] This latter practice has been all too much in evidence both post-Chernobyl and now Fukushima. Gofman noted in 1992: *"the current situation in radiation research is almost like reliance on the tobacco industry to conduct all the research on the health consequences from smoking. In radiation research, nearly all the work is sponsored by the governments which are defending and promoting nuclear power."*[77] Little has changed.

- The frequently cited 2003-2005 *Chernobyl Forum* health study that predicts no more than 4,000 accident-related fatal cancers in Belarus, Ukraine and Russia was published by the International Atomic Energy Agency (IAEA) in cooperation with the World Health Organization (WHO) and other agencies.[78] But the IAEA's mandate is to

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[76] http://www.amazon.com/Chernobyl-Forbidden-Truth-Alla-Yaroshinskaya/dp/0803299109 *Chernobyl: The Forbidden Truth.* Foreword by Dr. John Gofman. August 1, 1995.

[77] http://www.rightlivelihood.org/gofman_speech.html A Key Step in Protecting the World's Health. Right Livelihood Award acceptance speech by Dr. John Gofman. December 9, 1992.

[78] http://www.iaea.org/Publications/Booklets/Chernobyl/chernobyl.pdf *Chernobyl's Legacy: Health, Environmental Impacts and Recommendations to the Governments of Belarus, the Russian Federation and Ukraine.* IAEA. The Chernobyl Forum: 2003-2005. Second revised version.

promote nuclear technologies[79] and the agency has, since 1959, exercised a veto on any actions by the WHO that relate to nuclear power.[80]

- Investigations show that the *Chernobyl Forum* report focused only on the most heavily exposed areas in making its predictions and ignored the much larger populations in the affected countries themselves and in the rest of the world, who have been exposed to lower but chronic levels of radiation from Chernobyl.[81]

- International Physicians for the Prevention of Nuclear War (IPPNW) revealed that the *Chernobyl Forum* suppressed the facts in its own research. A close examination of the report on which the "official" 4,000 cancer fatality estimate was based revealed that 9,000 future fatal cancers were actually expected. The IAEA and WHO had manipulated their data by suppressing the estimates in their own research paper.[82]

- Given its control by the IAEA, the WHO cannot play *"its proper role in investigating and warning of the dangers of nuclear radiation on human health."*[83] Any WHO estimates of current or future health effects from nuclear accidents, including Fukushima, can therefore be viewed with a great deal of skepticism at best.

- In 2006, *The Other Report on Chernobyl* (TORCH) concluded that, *"depending on the risk factor used (i.e. the risk of fatal cancer per person-sievert), the TORCH Report estimates that the worldwide collective dose of 600,000 person-sieverts will result in 30,000 to 60,000 excess cancer deaths, 7 to 15 times the figure released in the IAEA's press statement."*[84]

- A Russian study by Dr.Yablokov et al. predicted at least a million eventual deaths from all causes due to the Chernobyl accident, while referencing 5,000 studies.[85]

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[79] http://www.iaea.org/About/about-iaea.html IAEA. The "Atoms for Peace" Agency.

[80] http://www.guardian.co.uk/commentisfree/2009/may/28/who-nuclear-power-chernobyl *Toxic link: the WHO and the IAEA.* By Oliver Tickell. The Guardian. May 28, 2009.

[81] http://www.jstor.org/discover/10.2307/4418166?uid=3739936&uid=2129&uid=2&uid=70&uid=4&uid=3739256&sid=21101838167847 *Twenty Years after Chernobyl. Debates and Lessons.* By M.V. Ramana. Economic & Political Weekly. May 6, 2006.

[82] Ibid. *Health Effects of Chernobyl. 25 years after the reactor catastrophe.*

[83] Ibid. *Toxic link: the WHO and the IAEA.*

[84] http://www.chernobylreport.org/torch.pdf. *The Other Report on Chernobyl (TORCH).* By Ian Fairlie, PhD., and David Sumner, DPhil. The Greens in the European Parliament. April 2006.

[85] http://www.amazon.com/Chernobyl-Consequences-Catastrophe-Environment-Sciences/dp/1573317578. *Chernobyl: Consequences of the catastrophe for people and the environment.* Yablokov et al./ Annals of the New York Academy of Sciences. January 2010.

A WEALTH OF STUDIES

A German study found that leukemia risks were more than doubled in young children within 5km of all German nuclear power plants.

- Epidemiological studies conducted by Dr. Steven Wing at the University of North Carolina-Chapel Hill in the aftermath of the Three Mile Island (TMI) nuclear accident that occurred on March 28, 1979 in Pennsylvania, concluded that exposures to accidental radioactive releases are related to increased cancer incidence around TMI.[86]

- Reactor accidents are not the only cause of health impacts from radiation exposure. A study funded by the European Commission estimated cumulative doses to the world population due to releases from the French La Hague nuclear waste reprocessing facility summed over 100,000 years. It concluded that, *"Assuming the same annual discharges for the planned remaining operational life of the La Hague facilities, the global, long-term collective dose due to La Hague would be 65,000 person-Sieverts, which implies a theoretical fatal cancer toll of 3,250 cases."*[87]

- Studies in Germany[88] and France[89] found elevated rates of leukemia among children living near nuclear power plants, with the numbers increasing in direct correlation to the proximity to the reactor site of the child's residence.

- The French study demonstrated a statistically significant doubling of the incidence of leukemia near to nuclear power plants in France between 2002 and 2007.[90]

- In Germany, the Federal Office for Radiation Protection found that in the vicinity of nuclear power plants, an increased risk of 60% was observed for all types of childhood cancer, and for childhood leukemia the risk doubled, equaling a risk increase of approximately 100%.[91]

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[86] http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1469835/ *A reevaluation of cancer incidence near the Three Mile Island nuclear plant: the collision of evidence and assumptions*. By Wing S, Richardson D, Armstrong D, Crawford-Brown D. Environmental Health Perspectives. 1997 Jan;105(1):52-7.

[87] http://fissilematerials.org/library/rr04.pdf. *Spent Nuclear Fuel Reprocessing in France.* By Mycle Schneider and Yves Marignac. A research report of the International Panel on Fissile Materials. April 2008.

[88] http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2696975/ *Childhood Leukemia in the Vicinity of Nuclear Power Plants in Germany.* Kaatsch et al. Deutsches Arzteblatt International. Octover 17, 2008.

[89] http://onlinelibrary.wiley.com/doi/10.1002/ijc.27425/abstract *Childhood leukemia around French nuclear power plants - The geocap study, 2002-2007.* Sermage-Faure et al. International Journal of Cancer. February 28, 2012.

[90] Ibid. *Childhood leukemia around French nuclear power plants - The geocap study, 2002-2007.*

[91] http://www.eea.europa.eu/publications/late-lessons-2/part-c-emerging-issues *Late lessons from Chernobyl, early warnings from Fukushima.* By Paul Dorfman, Aleksandra Fucic, Stephen Thomas. *Late lessons from early warnings: science, precaution, innovation.* European Environment Agency. February 4, 2013.

- Two independent medical studies around the La Hague reprocessing site in France found elevated rates of leukemia in young people living nearby.[92]

- A study of the Sellafield (UK) reprocessing facility found that there was a statistically significant increase in stillbirths among children born to fathers who worked at the reprocessing plant. A significant positive association was found between the risk of a baby being stillborn and the father's total exposure to external ionizing radiation before conception.[93]

- Using the Hiroshima and Nagasaki models to make health predictions related to the Chernobyl and Fukushima nuclear disasters, or even to routine exposures from nuclear reactors and reprocessing plants, is *"scientific absurdity."*[94] The Hiroshima and Nagaski models assessed populations there exposed to intense yet very short *external* radiation. Around the La Hague reprocessing plant, however, *"people living nearby permanently breathe and eat weakly contaminated elements in their air or food chain. They absorb very low levels but continuous doses of radiation inside the body resulting in internal contamination which is chronic and at very low levels. This is not the same system and the same model should not be used."*[95]

Children under five have been found, in studies, to be particularly susceptible to leukemia when living close to nuclear power plants. The closer the proximity, the higher the risk. (Photo: courtesy of J. Kamien. Hard Rain Project. © J.Kamien, UNEP.) www.hardrainproject.com.

[92] http://www.ncbi.nlm.nih.gov/pubmed/9006467 *"Case-control study of leukemia among young people near La Hague nuclear reprocessing plant: the environmental hypothesis revisited."* By Dominique Pobel, Jean-Francois Viel. British Medical Journal, No. 7074 Vol. 314, January 11, 1997. And: http://www.ncbi.nlm.nih.gov/pubmed/11413175 *"The incidence of childhood leukemia around the La Hague nuclear waste reprocessing plant (France): a survey for years 1978-1998.* By A-V Guizard, O. Boutou, D. Pottier, X. Troussard, D. Pheby, G. Launoy, R. Slama, A. Spira and ARKM. Journal of Epidemiology and Community Health, July 2001, Vol. 55, pp. 49-474.

[93] http://www.thelancet.com/journals/lancet/article/PIIS0140-6736(99)04138-0/fulltext. *Stillbirths among offspring of male radiation workers at Sellafield nuclear reprocessing plant.* Parker et al. The Lancet. October 23, 1999.

[94] Transcript, Dr. Bruno Chareyron, director, CRIIRAD laboratory, in the film, *Wastes: A Nuclear Nightmare.* 2009.

[95] Ibid.

HEALTH IMPACTS FROM CHERNOBYL

By 1992 it was estimated that 70,000 of the 830,000 Chernobyl liquidators were invalids and 13,000 had died; by 2006 the numbers rose to 50,000 to 100,000 deaths; and by 2010, to 112,000 to 125,000 deaths.

- For an analysis of the conflicts of interest of the WHO and IAEA, the agencies' suppression of their own data, and the more likely current and future estimates of deaths resulting from the April 26, 1986 Chernobyl accident, please see the "medical integrity" section beginning on page 22 of this report.

- The IAEA's obvious bias had already been revealed in 1991 in its conclusion that "*there is no clear pathologically documented evidence of an increase in thyroid cancer of the types known to be radiation related."*[96] Baverstock and Williams later in 2006 found that *"by far, the most prominent health consequence of the accident is the increase in thyroid cancer among those exposed as children. The medical authorities in Belarus and Ukraine were aware in 1990 that the incidence of the rare childhood thyroid cancer was increasing, particularly in children living close to the reactor."*[97]

- The fate of the estimated 830,000 Chernobyl liquidators – the civil and military personnel who were called upon to deal with consequences of the Chernobyl disaster – is hard to evaluate. They eventually returned to different parts of the former Soviet Union and only a small portion of them were subjected to regular examinations.[98] But by 1992 it was estimated that 70,000 liquidators were invalids and 13,000 had died.[99] By 2006, estimates rose to 50,000 to 100,000 deaths among liquidators.[100] By 2010, Yablokov et al estimated a death toll of 112,000 to 125,000 liquidators.[101]

- According to Russian authorities, liquidators are aging prematurely, and a higher than average number have developed various forms of cancer, leukemia, somatic and neurological psychiatric illnesses. A very large number have cataracts.[102]

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[96] International Chernobyl Project and International Atomic Energy Agency 1991.

[97] http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1570049/ *The Chernobyl Accident 20 Years On: An Assessment of the Health Consequences and the International Response.* By Keith Baverstock and Dillwyn Williams. Environmental Health Perspectives. May 30, 2006.

[98] Ibid. *Health Effects of Chernobyl. 25 years after the reactor catastrophe.*

[99] Ibid. And see: Strahlentelex 138-139/1992, 8, CIS: Bereits 13.000 tote Liquidatoren [13,000 liquidators already dead]. (German).

[100] See: E. Lengfelder et al.: 20 Jahre nach Tschernobyl: Erfahrungen und Lehren aus der Reaktorkatastrophe *[20 years after Chernobyl: Experience and lessons from the reactor catastrophe]* (German) Information from the Otto Hug Strahleninstitut – MHM, February 2006.

[101] Yablokov, AV (2009): M*ortality after the Chernobyl Accident,* in: *Ann N Y Acad Sci*, 2009 Nov;1181:192-216.

[102] Ibid. *Health Effects of Chernobyl. 25 years after the reactor catastrophe.*

- The UN Office for the Coordination of Humanitarian Affairs found a statistically significant increase of leukemia among Russian liquidators who were in service at Chernobyl in 1986 and 1987.[103]

- Those in the path of the Chernobyl plume in countries outside the former Soviet Union were neither tracked nor monitored. Therefore there has been no provable way for any who were sickened or died, to attribute this outcome conclusively to radiation exposure from Chernobyl. The combined effect of a low level of radiation exposure to large populations could be sizable.[104]

Photographs of Chernobyl liquidators displayed in tribute.

- More than half the Chernobyl fallout landed outside of the Ukraine, Belarus and Russia — in Europe, Asia and North America.[105] Fallout from Chernobyl contaminated about 40% of Europe's surface.[106]

- New DNA mutations in children born after the Chernobyl accident to irradiated parents, and living in non-contaminated territories, confirm the long-term health risks in the exposed population.[107]

- A peak in Down Syndrome cases was observed in newborns born in 1987 in Belarus, one year after the Chernobyl nuclear accident.[108] This phenomenon has been found around other nuclear sites. Abnormally high rates of Down Syndrome were found in the Dundalk, Ireland population possibly tied to the operation of the Sellafield nuclear waste reprocessing plant across the Irish Sea in Cumbria, England.[109]

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[103] United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA): 3rd International Conference, *Health Effects of the Chernobyl Accident, Results of 15-Year-Follow-Up Studies.* Conclusions. Kiev, June 4-8, 2001.

[104] Ibid. *Twenty Years after Chernobyl. Debates and Lessons.*

[105] Ibid. *The Other Report on Chernobyl (TORCH).*

[106] Ibid.

[107] Ibid. *Late lessons from Chernobyl, early warnings from Fukushima.*

[108] Ibid. *Late lessons from Chernobyl, early warnings from Fukushima.*

[109] http://www.irishhealth.com/article.html?id=6677 *Study raises Sellafield health risk.* By Niall Hunter. Irish Health. July 12, 2004.

31-year-old Julia of Kiev has just undergone thyroid removal surgery, leaving her with a scar often dubbed the "Belarus necklace." The continuing epidemic of thyroid pathologies experienced after the Chernobyl catastrophe in Belarus, Russia and Ukraine has resulted in an unprecedented and alarming number of such operations. Kiev, Ukraine, 2005. (Photo and caption: Gabriela Bulisova).

•Just because an illness is potentially "treatable" — such as thyroid cancer — does not mean it should be viewed as an acceptable consequence of a nuclear power plant accident. Such diseases — especially among children —represent pain and often life-long scars and impact emotional, social, and physical wellbeing.

•Mental distress is an inevitable health outcome given known risks of radiation. Therefore, it must be legitimately considered as a medical consequence of a nuclear disaster.

- Research by Pierre Flor-Henry and others into some of the psychological disorders resulting from Chernobyl show a clinical pathology related to radiation exposure.[110] For example, Flor-Henry found that schizophrenia and chronic fatigue syndrome among a high percentage of liquidators were accompanied by organic changes in the brain. This suggested that various neurological and psychological illnesses could be caused by exposure to radiation levels between 0.15 and 0.5 Sievert.[111]

- There are many other non-cancerous diseases caused by nuclear accidents that release radioactivity.[112] Childhood thyroid cancer for example, was found in epidemic proportions in former Soviet countries after Chernobyl, whereas in Poland, where potassium iodide pills —which protect the thyroid — were distributed, instances of childhood thyroid cancers were minimized.[113]

[110] Ibid. *Health Effects of Chernobyl. 25 years after the reactor catastrophe.*

[111] Ibid.

[112] Ibid. *Late lessons from Chernobyl, early warnings from Fukushima.*

[113] http://www.ncbi.nlm.nih.gov/pubmed/21049454 *Did the Chernobyl atomic plant accident have an influence on the incidence of thyroid carcinoma in the province of Olsztyn?* Bandurska-Stankiewicz et al. US National Library of Medicine. National Institutes of Health. Sep-Oct. 2010.

HEALTH IMPACTS FROM FUKUSHIMA

It is too soon to quantify the ultimate health impacts from Fukushima given the decades-long latency period for solid cancers triggered by radiation.

- The latency period for solid cancers triggered by radiation is typically 20 to 30 years, but can last for 60 to 70 years.[114] It is too soon to make any definitive claims about health impacts from the Fukushima nuclear disaster, whether fatal or otherwise.
- The most conservative predictive assessment of health impacts emanated from the WHO,[115] but its report *"fails in what should have been its most important task – i.e. to calculate collective doses to the people of Fukushima, to the people of Japan and to the people of the Northern Hemisphere from the Fukushima accident."*[116]
- One early study predicted 125 eventual cancer-related fatalities worldwide,[117] while another predicted 1,000.[118] Fairlie calculated collective doses at about 3,000 fatal cancers in the Fukushima Prefecture alone.[119] But: *"Considerable uncertainties surround my estimates. They should only be used as rough guides."*[120]
- Of primary concern are fission products, readily absorbed by the human body, such as cesium-137 which represents the most significant long-term hazard, since it is readily taken up in human metabolic, environmental, and agricultural systems.[121]

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[114] Personal communication to author from Dr. Ian Fairlie.

[115] http://apps.who.int/iris/bitstream/10665/78218/1/9789241505130_eng.pdf *Health Risk Assessment from the nuclear accident after the 2011 Great East Japan Earthquake and Tsunami based on preliminary dose estimation.* World Health Organization. February 2013.

[116] http://www.ianfairlie.org/news/who-health-risk-assessment-from-the-nuclear-accident-after-the-2011-great-east-japan-earthquake-and-tsunami/ W*HO Health risk assessment from the nuclear accident after the 2011 Great East Japan Earthquake and Tsunami.* Ian Fairlie. Fairlie.org. February 28, 2013.

[117] *Worldwide health effects of the Fukushima Daiichi nuclear accident.* John E. Ten Hoeve and Mark Jacobson. Energy & Environmental Science. June 26, 2012.

[118] *Accounting for long-term doses in* "*Worldwide health effects of the Fukushima Daiichi nuclear accident."* Jan Beyea, Edwin Lyman, Frank N. von Hippel. Energy & Environmental Science. January 8, 2013.

[119] http://www.ianfairlie.org/news/assessing-long-term-health-effects-from-fukushimas-radioactive-fallout/ *Assessing long-term Health Effects from Fukushima's Radioactive Fallout.* Dr. Ian Fairlie. March 3, 2013. IanFairlie.org.

[120] Ibid.

[121] Ibid. *Late lessons from Chernobyl, early warnings from Fukushima.*

BANANAS AND OTHER RED HERRINGS

"When you eat a banana, your body's level of Potassium-40 doesn't increase. You just get rid of some excess Potassium-40. The net dose of a banana is zero."[122]

- The tiny radiation exposure due to eating a banana lasts only for a few hours after ingestion, namely the time it takes for the normal potassium content of the body to be regulated by the kidneys. Since our bodies are under homeostatic control, the body's level of potassium-40 doesn't increase after eating a banana. The body just gets rid of some excess potassium-40.[123]

- Exposure to cosmic radiation from airplane travel is one hundredth of the annual "allowable" limit of 1 mSv.[124] ("Allowable," however, does not mean "safe.)" But to put this in perspective, the radiation from a typical flight is less than half the radiation dose you receive from a chest x-ray.[125] And external radiation is only dangerous for the time a person is close to the source. This is very different from *internal* exposure.

- Many of the man-made radioactive nuclides released from nuclear power facilities, from atomic bomb tests and from accidents like Fukushima and Chernobyl, are mistaken by the human body for more familiar elements. For example, ingested radioactive strontium-90 replaces stable calcium, and ingested radioactive cesium-137 replaces stable potassium. These nuclides can thus lodge in bones and muscles and irradiate people from within.[126] This is internal radiation.

- Cosmic radiation, or uranium and its daughter products which exist in water supplies, and radon released from underground, are inescapable and not without risk themselves. But radioactivity released by nuclear facilities or atomic bombs unnecessarily adds to our exposure burden and the longevity of radiation in our bodies. Cesium-137, which does not exist in nature, is "impossible to avoid."[127]

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[122] http://www.washingtonsblog.com/2013/04/fake-science-alert-fukushima-radiation-cant-be-compared-to-bananas-or-x-rays.html Quote from Geoff Meggitt, retired health physicist, former editor of the Journal of Radiological Protection.

[123] Ibid George Meggitt.

[124] Ibid. Communication to author from Dr. Ian Fairlie.

[125] http://www.epa.gov/radtown/cosmic.html Cosmic Radiation During Flights. US EPA.

[126] Ibid. Communication to author from Dr. Ian Fairlie.

[127] http://www.epa.gov/radiation/radionuclides/cesium.html#protectmyself Radiation Protection, US EPA.

FRANCE

France does not "recycle" radioactive waste. It has no repository and stores more than 80 metric tons of plutonium in small canisters with nowhere to go.

- France's heavy reliance on nuclear energy has resulted in a huge, unsolved, radioactive waste problem.[128] Like every other country in the world, France is without an operating high-level radioactive waste final disposal facility.[129]

French high-level radioactive waste that is too contaminated for "re-use," is stored at the Pierrelatte nuclear facility. A small amount of that waste — including uranium hexafluoride — was transported to Siberia where it is stored in outdoor canisters viewable from Google Earth. This revelation was made in the French documentary - Wastes: A Nuclear Nightmare. (See: http://www.arte.tv/fr/dechets-le-cauchemar-du-nucleaire/2766888.html)

- France reprocesses[130] irradiated fuel from its reactors at its La Hague facility on the Normandy peninsula. Reprocessing results in more waste (by volume).[131]

- La Hague discharges tens of millions of gallons of so-called "low-level" radioactive waste into the English Channel every year. These liquid wastes have been detected as far away as the Arctic. Radioactive krypton-85 gas released by La Hague has been found at concentrations 90,000 times higher than in nature.[132]

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[128] http://www.beyondnuclear.org/storage/documents/France_Pamphlet_Summer20102.pdf *Nuclear Power in France: Setting the Record Straight. The not so rosé truth about the French nuclear power program.* A Beyond Nuclear pamphlet. Summer 2010.

[129] http://beyondnuclear.squarespace.com/storage/France_Fact_Sheet_09.pdf. *Nuclear Power in France: Setting the Record Straight.* A Beyond Nuclear Fact Sheet. 2009.

[130] Reprocessing involves physically chopping up the irradiated fuel rods after they have been removed from a nuclear power reactor and then dissolving them in acid to extract plutonium and uranium. For more see the Beyond Nuclear pamphlet on Reprocessing.

[131] Ibid.

[132] http://www.commondreams.org/pressreleases/Nov%2098/110998g.htm *La Hague radioactive air 90,000 times higher than background.* Greenpeace, November 9, 1998.

- Originally posted on the website of *Pandora's Promise*, but then removed, Stone wrote of his "AHAH moment": *"I was granted entry into a room in France (the size of a basketball court) where all the waste from powering 80% of the country for 30 years is stored."*[133] But only 4% of French high-level reprocessed and vitrified radioactive waste is stored in that room.[134] Most wastes are too contaminated for re-use and are stored in the Pierrelatte facility in the south of France. They are described as "recyclable" but are not in fact recycled.[135]

- More than 80 metric tons of separated plutonium are stored at La Hague in thousands of small canisters, an incredible security and nuclear weapons proliferation risk. A small portion of that plutonium is "reused" in some reactors that in turn produce more plutonium as part of the fission process.

- The development of a deep geologic repository for high-level and medium-activity long-lived waste in France is focused on a site near Bure, in the Meuse/Haute-Marne region. There is currently an underground laboratory at the site but no operating repository.

- So-called "low-level" and "intermediate-level" radioactive waste in France has been taken to the Storage Center at Aube in the Champagne region, where it is documented to be leaking into groundwater.[136]

- Radioactive mine tailings from France's 210 abandoned uranium mines have been found in playgrounds and public parking lots. Liquid effluent from the mines has rendered stream sediment around the disused sites equivalent to radioactive waste.[137]

- France banked on a plutonium "breeding" program as the basis for its massive nuclear power program. But uranium proved plentiful and plutonium uneconomic as a fuel. The country's flagship breeder reactor – the Superphénix – was a costly disaster, producing just 8.2 TWh of electricity in its 12 years of operation – a lifetime capacity of less than seven percent.[138]

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[133] http://www.beyondnuclear.org/storage/documents/Stone%20Director's%20Note%20captured.pdf Captured *Pandora's Promise, Director's Note.* By Robert Stone. Formerly posted as "Director's Note" on the Pandora's Promise website, here, http://pandoraspromise.com/directors-note/#.UXcX9BlUjJx, but since removed.

[134] Ibid. *Nuclear Power in France: Setting the Record Straight. The not so rosé truth about the French nuclear power program.*

[135] http://www.arte.tv/fr/dechets-le-cauchemar-du-nucleaire/2766888.html See the Areva spokesman in the documentary: *Wastes: A Nuclear Nightmare.*

[136] http://www.citizen.org/documents/Burnie%20paper%20on%20French%20reprocessing.pdf *French Nuclear Reprocessing – Failure at Home, Coup d'Etat in the United States.* Page 5. By Shaun Burnie. May 2007.

[137] http://www.criirad.org/actualites/uraniumfrance/Synthese_PDF/anglais.pdf *Radiological Hazards from Uranium Mining. By* Bruno Chareyron. CRIIRAD report. 2011.

[138] Ibid. *Fast Breeder Reactors in France.* By Mycle Schneider. Science and Global Security. 2009.

France has an active anti-nuclear movement with more than 900 organizations around the country. At left, 5,000 rallied in 2009 in Colmar, France, demanding the closure of the country's oldest nuclear power plant at Fessenheim, on the border with Germany. The country's heavy dependence on nuclear-provided electricity means it must import electricity from Germany and elsewhere in winter when demand is high due to the use of electric heat. During summer droughts and heatwaves France cannot rely on reactors which must power down or close when water supplies are too low or too hot. (Photo: Linda Pentz Gunter).

- France has experienced a long list of accidents and serious problems - as many as 1,000 in some years. [139]Some of the most serious are listed at *Dossiers de la Redaction,*[140] and on the *Huffington Post*.[141]

- A cascade of accidents in the summer of 2008 included leaks and spills from several French nuclear facilities, particularly those at the huge nuclear complex at Tricastin, where radioactive contamination of two rivers resulted in a ban on drinking and bathing in the water. Tricastin area wine growers saw their businesses suffer, forcing them to change the name of their wine;[142] farmers struggled to sell their produce while homeowners watched their property values plummet.[143]

[139] http://www.planet.fr/dossiers-de-la-redaction-nucleaire-les-accidents-plus-graves-en-france-et-dans-le-monde.57360.1466.html *Nucléaire: les accidents les plus graves en France et dans le monde. (Nuclear: the most serious accidents in France and around the world.)*

[140] Ibid.

[141] http://archives-lepost.huffingtonpost.fr/article/2011/09/13/2589236_la-liste-des-incidents-nucleaires-francais-depuis-30-ans.html. *La liste des incidents nucléaires français depuis 30 ans.*

[142] *'Radioactive' wine renamed.* Grapes in the News. June 9, 2010.

[143] http://www.leparisien.fr/abo-faits-divers/au-tricastin-les-riverains-etudient-les-suites-a-donner-28-07-2008-102700.php *Au Tricastin, les riverains étudient les suites à donner.* Le Parisien. July 28, 2008.

GERMANY

Germany has already created 380,000 long-term jobs in the renewable energy sector compared to 30,000 in the nuclear power sector.

Solar panels on rooftops in Germany. Rural co-ops and a grid-priority feed-in tariff have stimulated the renewable energy grid contribution to close to 25% in 2013, with a goal of 80% to 100% by 2050.

- Germany is phasing out all its nuclear plants and aiming for an 80-100% renewable energy economy by 2050. The 380,0000 new jobs[144] already created in the renewable energy sector, for technicians, carpenters, farmers, steelworkers, architects, project developers and banks, are local and can't be exported. By contrast, prior to the recent shutdowns, the nuclear sector employed just 30,000 people.[145]

- The recognition that renewable energy can revitalize stagnant and struggling domestic industries and seaports, while reducing carbon emissions and avoiding the health and environmental risks of nuclear and fossil fuels, has spurred cross-party support for the development of renewable energy technologies.

- Renewable energy development in Germany has revitalized a chain of supply that has stimulated industries across the country. For example, in the case of offshore wind, the industries that support it are found in inland provinces far from the coast.

- Germany's progress toward a 100% renewable energy economy shows that renewable energy, along with maximized energy efficiency, can supplant nuclear power (and coal) and create more jobs as well. It is not a question of coal or nuclear. Both of these technologies can — and must — be phased out.

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[144] http://www.bloomberg.com/news/2013-05-15/u-s-energy-policy-should-take-a-lesson-from-germany-s-energiewende.html *U.S. Energy Policy Should Take a Lesson From Germany's Energiewende.* By Rainer Baake and Jennifer Morgan. Bloomberg. May 15, 2013.

[145] http://www.simplyinfo.org/?p=9521. *German Push for Renewable Energy Creates Job Boom*. Simply Info. And www.unendlich-viel.energie.de February 1, 2013.

CONCLUSIONS

Nuclear power reactors of any design are too slow and expensive to build; too fraught with inherent risks; and utterly lacking in any plan for the long-lived radioactive wastes they produce to serve any useful purpose in the cause of mitigating climate change.

The interest in so-called *Generation IV* reactors — including the Integral Fast Reactor, small modular reactors and thorium-fueled reactors — is divorced from the practical realities of today's climate crisis-troubled world. These reactors have high capital costs; sodium-cooled breeder reactors are prone to serious fires that could lead to catastrophic accidents; they will continue to add to the stockpile of radioactive nuclear waste; and they are too complex to deploy rapidly enough to serve any useful or realistic purpose in addressing global climate change.

The commercial potential of the IFR, and even small modular reactors, is even less attractive than that of current light-water reactors, whose steady global retreat reflects the financial decline of an outdated industry.

The IFR cannot make radioactive waste disappear but would theoretically transmute it. A disposal facility would still be needed. New designs for fast reactors, used as burner reactors, are mostly untested paper studies.

Renewable energy, such as offshore wind and geothermal, are capable of providing reliable base load energy. However, base load electricity is not necessarily the answer. Many developing nations have large rural populations and are better served by distributed generation provided by renewable energy. Even in developed countries, distributed generation makes sense. In Germany, for example, the cooperative model is being successfully utilized for renewable energy production.

Numerous studies, and the example of Germany, show renewables and energy efficiency can replace fissile and fossil fuels, and create more — and long-lasting — jobs as well. It is not a question of coal or nuclear. Both of these technologies can — and must — be phased out.

Even before deploying renewables on a large scale, conservation and using energy more efficiently can negate the need to replace aging nuclear power plants entirely.

It is hard to understand how the nuclear deniers can persist in citing the lowball number of 4,000 eventual Chernobyl-caused cancer fatalities in Russia, Belarus and Ukraine,

predicted by the World Health Organization. These numbers have been utterly discredited, while the WHO remains under the thumb of the IAEA whose explicit mission is to promote nuclear energy.

The wealth of health studies around Chernobyl suggest that a reasonable estimate of eventual worldwide cancer-related fatalities lies at least in the tens, if not the hundreds of thousands based on independent research. Overall deaths from multiple causes could soar even higher.

It is not a question of coal or nuclear. Both of these technologies can - and must - be phased out.

The definitive medical consequences of Fukushima will remain unknown for decades. Many health outcomes are possible but may not manifest even in present generations. Cancers caused by exposure to radiation can take many decades to appear.

There is no such thing as a “pro-nuclear environmentalist” unless the definition of “environmentalist” is to be radically altered. Environmentalists do not support extractive, non-sustainable industries like nuclear power which poisons the environment; releases cancer-causing radioactive elements; creates radioactive waste and, if there is an accident, can render vast areas permanent sacrifice zones.

Promoting the worldwide commercialization of a reactor that uses plutonium as an answer to climate change puts weapons-usable materials and technology in the hands of nations and rogue actors that could misuse it. It could encourage the use of nuclear weapons which could have serious and immediate consequences on the global climate. Even a “small” nuclear war could precipitate rapid climate change and result in global agricultural collapse similar to the effects of a nuclear winter.

Just as it cannot address climate change effectively, economically, safely or in time, nuclear power is not useful as a solution to the world’s growing energy needs.

We are systematically – and unfortunately not so slowly – destroying the planet through human-caused climate change. There is no need to substitute Global Warming with Nuclear Winter.

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Beyond Nuclear, 6930 Carroll Avenue, Suite 400,
Takoma Park, MD 20912. 301.270.2209.
Info@BeyondNuclear.org. www.BeyondNuclear.org
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